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(54) Alternate cell routing for cellular mobile radio

(57) A method for processing Cellular Mobile Radio Service (CMRS) telephone calls during cell voice channel congestion provides that, when the system receives a request for service (either a mobile originating call or a call terminating to a mobile) which would normally be denied because of cell voice channel congestion, the system can directly select an idle voice channel in other cells which have coverage areas overlapping the coverage area of the cell or cell sector wherein the subscriber is located. Direct selection is accomplished by the use of a routing table containing alternate routes. The table members of the alternate routes are the available voice channels in the other cells. The communication to the mobile to tune to the selected voice channel in the new cell is sent to the mobile via the control channel of the current cell as is done in the cases of either a denial or a directed retry command.

Fig.6.

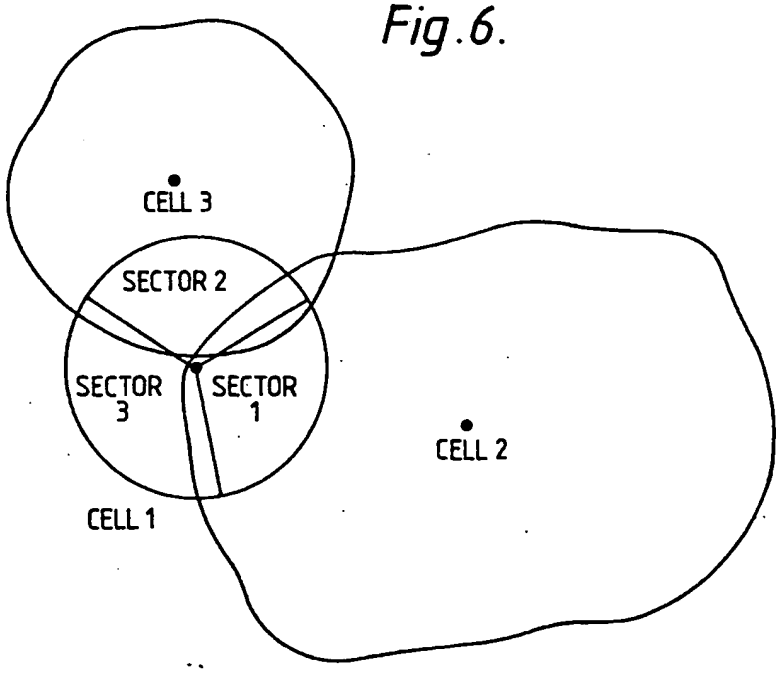

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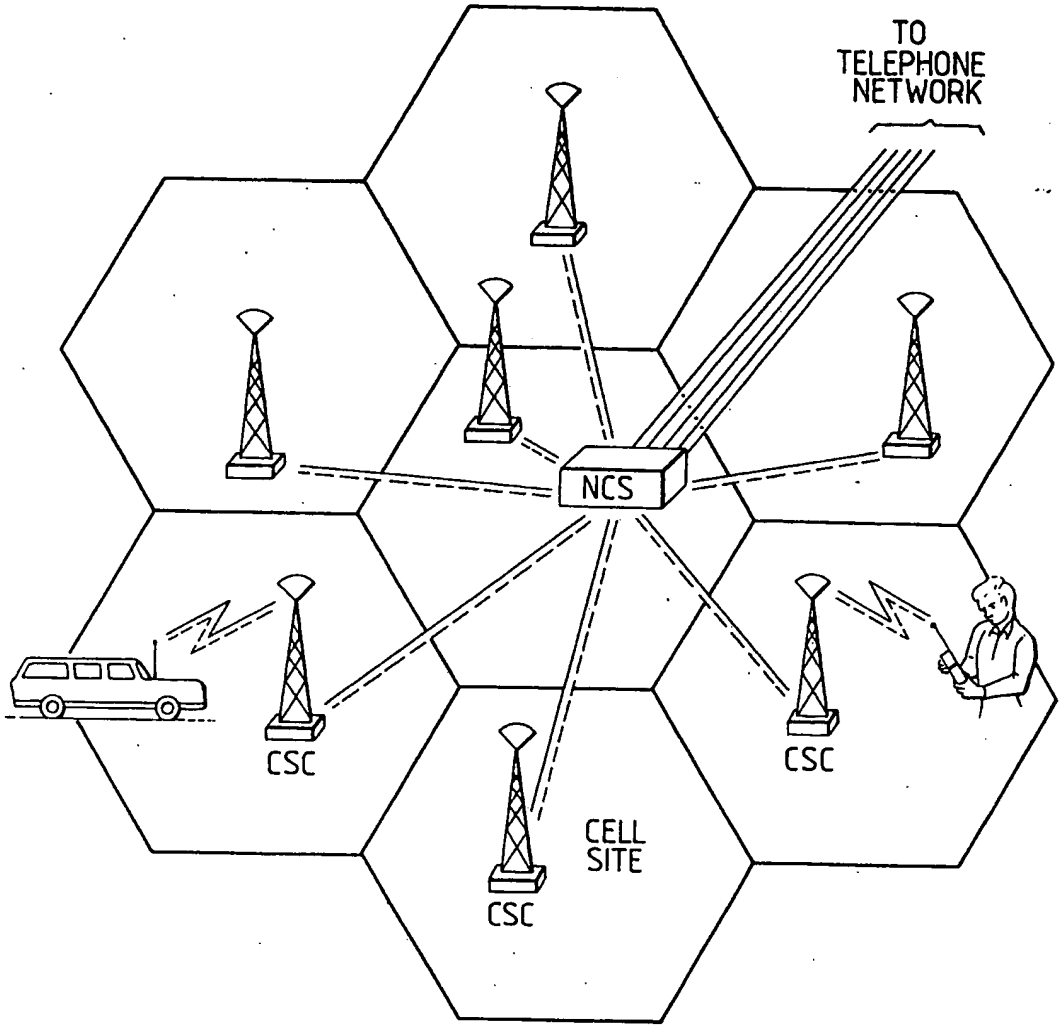
Fig.1.



——— VOICE

- - - - - DATA

NCS NETWORK CONTROL SYSTEM

CSC CELL SITE CONTROL SYSTEM

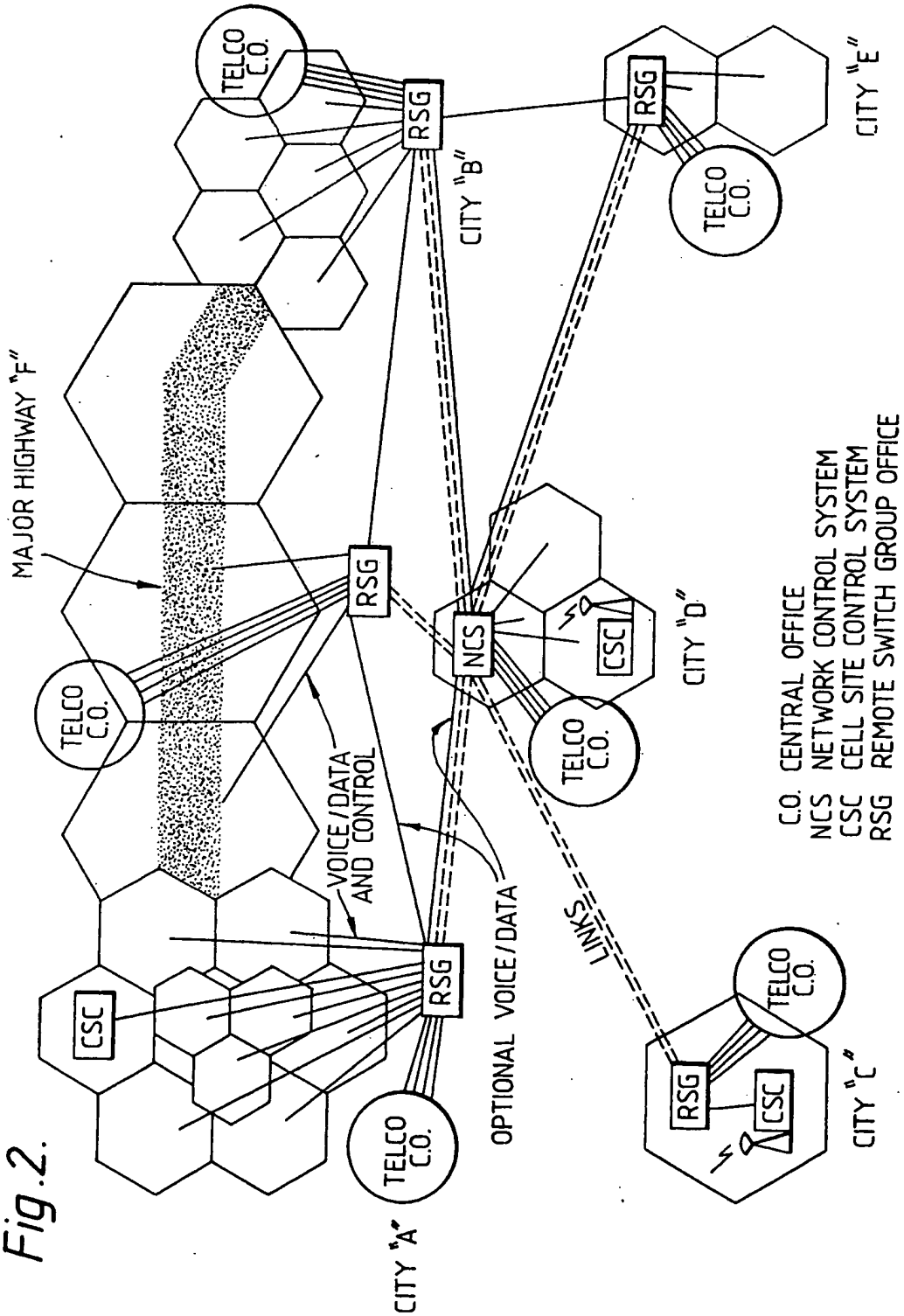

TELCO C.O.
RSG
CITY "B"
CITY "E"
MAJOR HIGHWAY "F"
NCS
CSC
CITY "D"
VOICE/DATA AND CONTROL
OPTIONAL VOICE/DATA LINKS
CITY "A"
CITY "C"
C.O. CENTRAL OFFICE
NCS NETWORK CONTROL SYSTEM
CSC CELL SITE CONTROL SYSTEM
RSG REMOTE SWITCH GROUP OFFICE

Fig.2.

Fig.3.

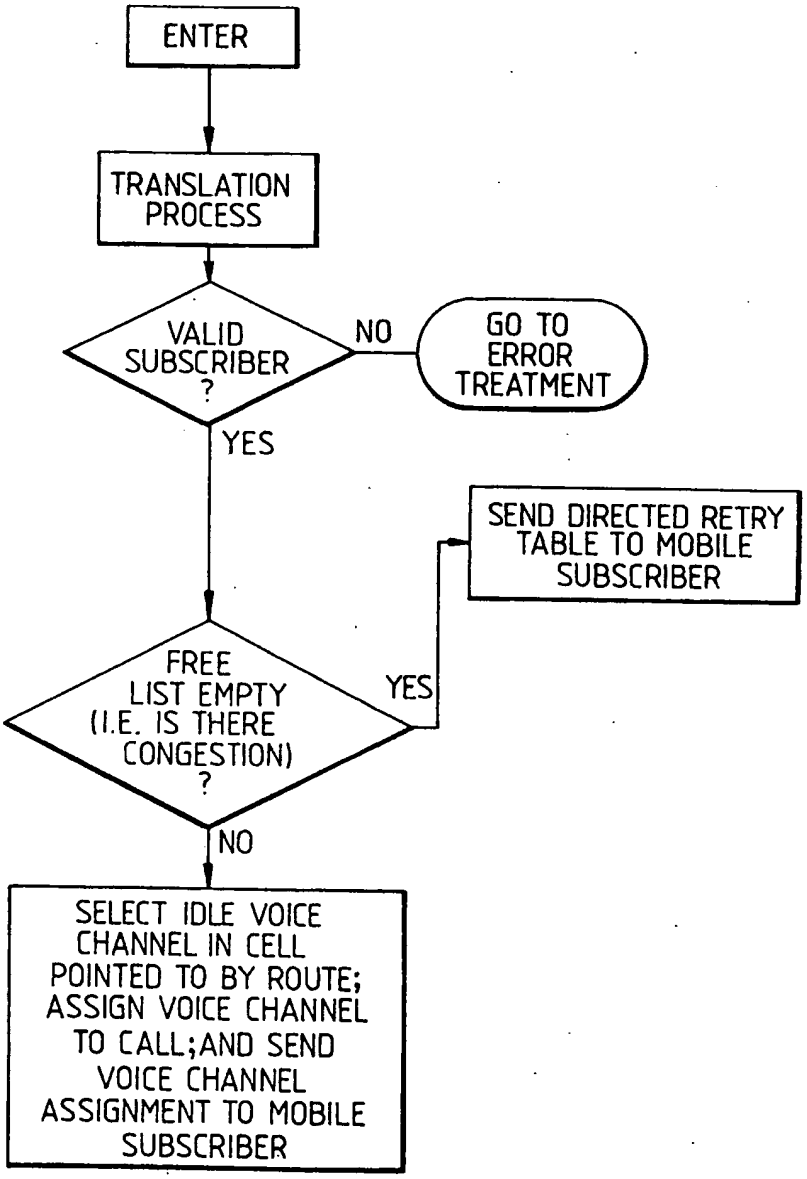

ENTER
TRANSLATION PROCESS
VALID SUBSCRIBER ?
NO
GO TO ERROR TREATMENT
YES
SEND DIRECTED RETRY TABLE TO MOBILE SUBSCRIBER
FREE LIST EMPTY (I.E. IS THERE CONGESTION) ?
YES
NO
SELECT IDLE VOICE CHANNEL IN CELL POINTED TO BY ROUTE; ASSIGN VOICE CHANNEL TO CALL; AND SEND VOICE CHANNEL ASSIGNMENT TO MOBILE SUBSCRIBER

Fig. 4.

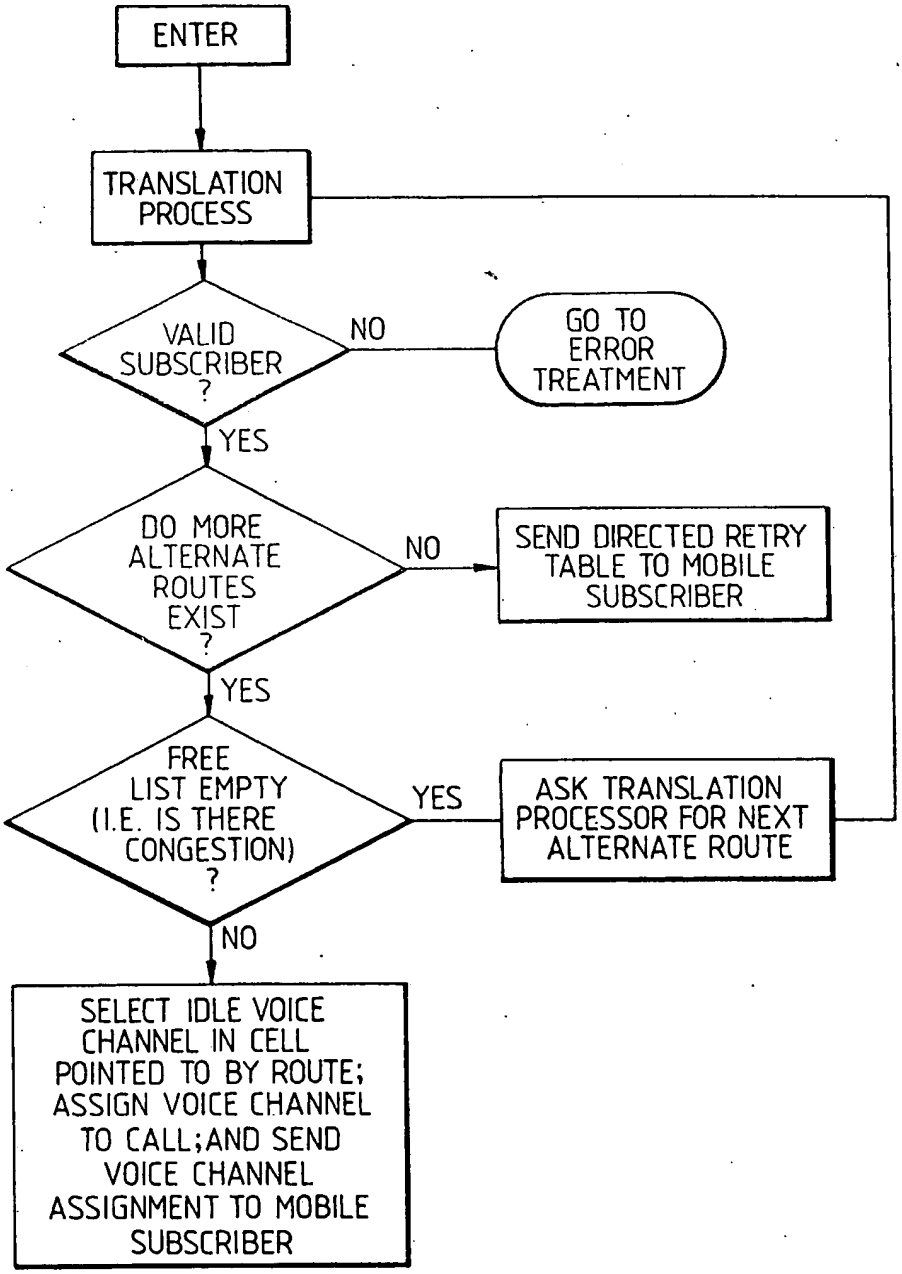

ENTER
TRANSLATION PROCESS
VALID SUBSCRIBER ?
NO
GO TO ERROR TREATMENT
YES
DO MORE ALTERNATE ROUTES EXIST ?
NO
SEND DIRECTED RETRY TABLE TO MOBILE SUBSCRIBER
YES
FREE LIST EMPTY (I.E. IS THERE CONGESTION) ?
YES
ASK TRANSLATION PROCESSOR FOR NEXT ALTERNATE ROUTE
NO
SELECT IDLE VOICE CHANNEL IN CELL POINTED TO BY ROUTE; ASSIGN VOICE CHANNEL TO CALL; AND SEND VOICE CHANNEL ASSIGNMENT TO MOBILE SUBSCRIBER

Fig.5.

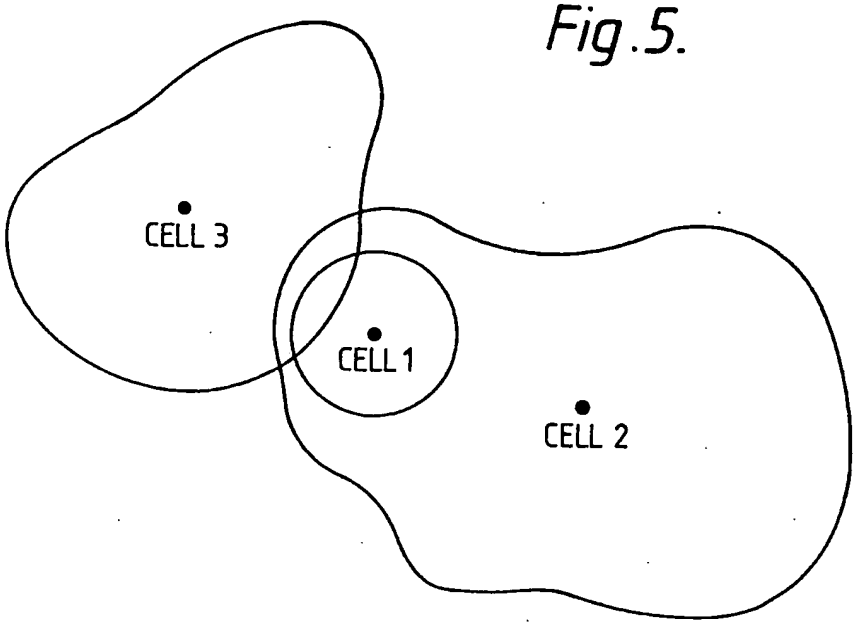
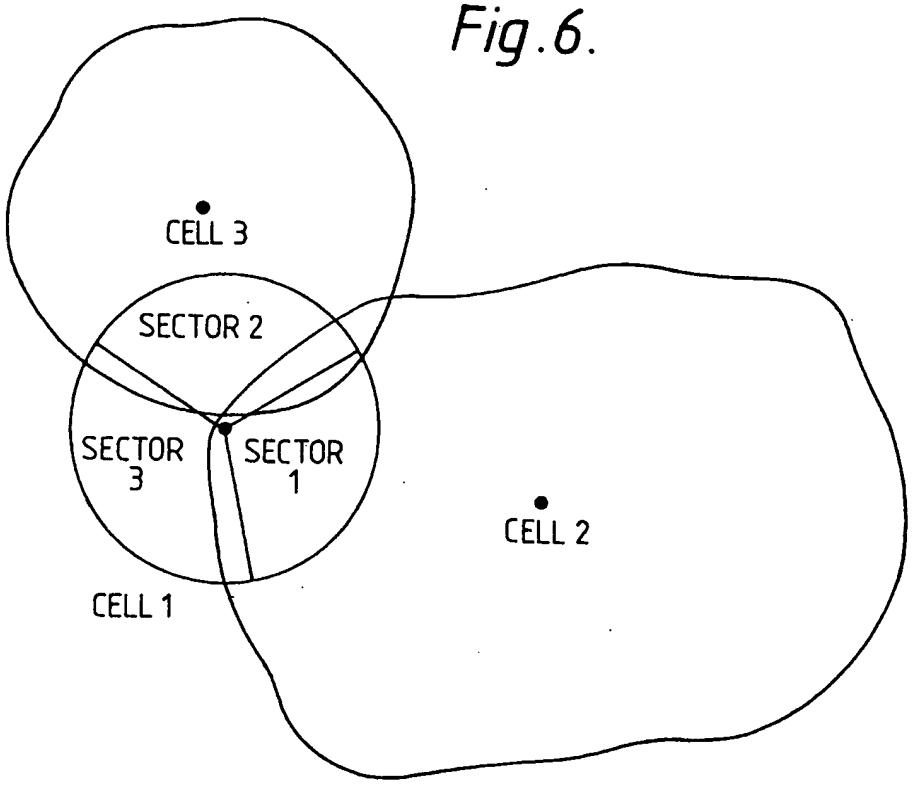

CELL 3
CELL 1
CELL 2

Fig.6.


CELL 3
SECTOR 2
SECTOR 3
SECTOR 1
CELL 2
CELL 1

SPECIFICATION

Alternate cell routing for cellular mobile radio

This invention relates to cellular mobile radio-telephony systems and, more particularly, to a method for processing calls during congestion when the selected serving cell does not have an available voice channel at the time of the call attempt.

Systems of interest in understanding cellular mobile radio are disclosed in United States patent applications entitled "Cellular Mobile Radio Service Telephone System" Serial No. 457,155, filed January 11, 1983, U.S. Serial No. 622, 939, filed June 21, 1984, entitled "Data Control For Telephone System"; U.S. Serial No. 619,251, filed June 11, 1984, entitled "Hand-Off Filter For Cellular Mobile Radio"; and U.S. Serial No. 622, 941, filed June 21, 1984, entitled "Cellular Mobile Radio Hand-Off Utilizing Voice Channel", which applications are incorporated by reference herein in their entirety.

Cellular radio-telephony is used at numerous sites in many countries. Such a telephone system permits communication between two mobile telephone stations as well as between a mobile station and a fixed station.

Cellular Mobile Radio Service (CMRS) is a fully automatic radiotelephone service for use by mobile, portable, or stationary units specifically designed with sophisticated digital controls and logic. The radiotelephone units utilise radio frequency to communicate with low power, limited radiation base transceivers in a cellular pattern making it necessary for the system to locate each mobile unit and follow it enroute by handing off in-progress calls between cells. The low power, limited radiation elements of CMRS systems allow a unique frequency distribution and reuse scheme to provide sufficient channels to serve any number of subscribers (e.g., 100,000).

The mobile radios are intelligent units; that is, they contain a microprocessor or an equivalent logic element. They store certain permanent information (e.g., unit manufacturer's serial number), semi-permanent information (e.g., registration memory), temporary memory containing individual call data and timers, etc. In the United States, as a result of FCC regulations, each unit can access 666 radio channels but must manually or automatically select either an upper band of 333 radio channels or a lower band. Current FCC rules allocate the upper band to a non-wire line RCC and the lower band to a telco-owned RCC.

Such systems are formed of clusters of cells wherein each cell is assigned a predetermined set of voice channels, the bands being spaced apart in the frequency spectrum so as to permit simultaneous transmission of many telephone conversations by many stations without interference between communications in the various bands. In order to ensure that there is no interference between the assigned frequency bands of one cell and the assigned frequency bands of a contiguous cell, the bands in the contiguous cell are located at different portions of the frequency spectrum from the bands of the first-mentioned cell. The same frequency bands are repeated at more remote cells, and the power of signal transmission in any one band is limited in amplitude so as to become attenuated to a sufficiently low, non-interfering level at the frequency bands of the remote cell.

Cellular mobile radio-telephone systems are described in the technical literature. One such system referred to as an "Advanced Mobile Phone Service" is described in the *Bell System Technical Journal*, January 1979, Vol. 58, No. 1, pp 1–269.

Multiplexing of individual subscriber channels for communication via common radio frequency (RF) links is accomplished, preferably, by means of statistical multiplexers. Such multiplexers are described in an article entitled "Controlling Data Communications: Statistical Multiplexer Moves In" by H.J. Hindin in *Electronics*, July 28, 1981, pp 141–148, and in "A Buyers Guide to Today's Volatile Statistical Multiplexers" by J.H. Scharen-Guivel and A.A. Carlson in *Data Communications*, March 1982, pp 97–126. A switching configuration for a mobile system is disclosed in "A Distributed Switching Approach to Cellular Coverage" by R.E.Pickett in Telecommunications Magazine, February 1983. A network control system for use in cellular mobile radio-telephony may include the commercially available ITT System 1210 hardware and software.

In the construction of a cellular system, a group of the foregoing cells is clustered about a system switching network or piece of the network which allocates the available frequency bands in any one cell among the various mobile radio-telephones with which communication is desired. Such switching networks provide for the coupling of a telephone conversation of one frequency band in a first cell with a second frequency band in a second cell or, alternatively, with a long-distance trunk circuit which connects the first cell with a desired cell in another cluster or a land subscriber. In addition, well-known control circuitry is provided for the transmission of command signals to the mobile stations for directing their respective transmissions on the allocated frequency bands.

In known cellular systems, during the time that a particular cell has all of the voice channels assigned to previous calls, and thus has voice channel congestion, new requests for mobile

service, i.e., voice channel assignment, are denied by that cell. The denial communication sent to the mobile on the control channel in that cell may be absolute or it may optionally include a list of other cells where the mobile may have more success in obtaining a voice channel assignment. This communication is called a "directed retry" in the industry. The directed retry procedure requires the mobile unit to retune to the control channel of one of the suggested cells and to retransmit all of the specific call detail information. This procedure takes considerable real time (the time must be added to the other set up times and thus increases the call delay perceived by the human originating the call), represents additional processor load on what may be an already busy system, increases occupancy on the control channels of the current cell as well as of the new cell, and does not ensure success on the new attempt.

During intervals of relatively low traffic volume, such additional burdens, to support directed retry traffic in both mobile originating and mobile terminating call cases on the system, may not substantially degrade the overall number of telephone communications which can be simultaneously handled. However, during intervals of relatively large volumes of telephone traffic, such a burden may limit the amount of telephone communications which can be handed by the system.

According to the invention there is provided a method for routing cellular mobile radio telephone calls, comprising monitoring cell call activity for assignment of an idle voice channel to a mobile subscriber, and directing the mobile subscriber to an idle voice channel in another cell in response to detection of cell call congestion.

In accordance with the principles of the invention, when the system receives a request for service (either a mobile originating call or a call terminating to a mobile) which would normally be denied because of cell voice channel congestion, the system can directly select an idle voice channel in other cells which have coverage areas overlapping the coverage area of the cell or cell sector wherein the subscriber is located. Direct selection is accomplished by the use of a routing table containing alternate routes. The table members of the alternate routes are the available voice channels in the other cells. The communication to the mobile to tune to the selected voice channel in the new cell is sent to the mobile via the control channel of the current cell as would have been the case for the denial or directed retry command.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:–

Figure 1 is a diagrammatic view of a cellular mobile radio telephone system showing the various communication links whereby control and data signals are transmitted among mobile subscribers, stationary subscribers, and the transceiving stations of the respective cells;

Figure 2 is a block diagram of a CMRS system utilising remote switch groups, as shown in the aforementioned United States patent application entitled "Cellular Mobile Radio Service Telephone System" Serial No. 457,155, filed January 11, 1983;

Figure 3 is a flow chart of a known directed retry algorithm;

Figure 4 is a flow chart of an algorithm disclosing a featured of the invention;

Figure 5 is a diagram of the coverage areas of three cells useful in describing the invention; and

Figure 6 is a diagram of the coverage areas of three cells, including a sectored cell useful in describing the invention.

The CMRS system of Fig. 1 illustrates an arrangement having 7 cells each having voice and data connections to a network control system (NCS). The NCS is in turn connected to the telephone network. Each cell uses one or more of 21 channels as set-up channels to broadcast continuously certain routine or overhead information which permits the mobiles to select the nearest cell, identify the system, etc. the CMRS system continuously transmits digital data on each cell set-up channel including such information as the CMRS system identification, overload control (line load control), synchronising bits, busy-idle status of reverse signalling channel and signalling channel numbers used in this location.

If a call were to be made to a Home Mobile Unit (HMU) directory number, the system would try to page it by sending out the car directory number on paging (set-up) channels. Receiving no response, the NCS can return such an indication to the calling subscriber in the form of an announcement. If the called mobile unit is turned on and answers the page, the mobile will be rung and the caller will receive ringback tone indicating that the mobile is in the area and turned on. When the mobile unit first turns on his radiotelephone, it first scans all set-up channels. The unit would verify that it was in its home area and the paging (or set-up) channels and voice channels used in this complex would be identified to the mobile unit. The mobile unit would then scan the identified set-up channel and select and tune to the strongest one, presumably the nearest cell transmitter. Busy-idle bits inform the mobile unit of the status of the reverse (mobile to base) signalling channel to prevent simultaneous seizure by more than one mobile unit. There are also other handshake and timing checks to guard against collisions.

The mobile unit now automatically reports in to the system and sends its unit serial number, its assigned telephone number (7 or 10 digits), its power level, etc. and turns off its transmitter, continuing to monitor the selected set-up channel for a page.

The NCS registers the mobile unit as either a home or foreign unit. Depending upon system procedures, the registration could verify that service has not been discontinued, or is not on a hot list relating to unauthorised use or stolen units.

On a call to a mobile, the NCS directs the paging (7 digit number) to be sent on the appropriate paging channels. The mobile receives the page and detects that it coincides with its assigned telephone number. It acknowledges on a selected set-up channel by sending back its identification number. The NCS assigns a voice channel and advises the mobile to switch to that channel, abandoning the set-up channel. The mobile acknowledges that he is now tuned to the assigned voice channel by an in-band SAT (supervisory) tone. The NCS directs the base RF equipment to send an alerting data burst over the voice channel and the mobile begins the audible alert (ringing). The mobile returns an out of band signalling tone acknowledging that it is in a ringing process and the NCS returns ringback to the calling party. When the mobile is answered, the signalling tone is removed and the call cut through.

When no voice channels are available in the cell where the mobile responds to the page due to congestion, the call does not progress to a voice channel assignment and an alerting (ringing) of the mobile.

On a call from a mobile, if the mobile has signed in with his radio on, he will already be registered in the NCS as a bona fide unit. To initiate a call, the mobile subscriber will enter the dialled digits of the called number and they are temporarily stored in the mobile unit. Then the mobile goes off-hook and scans and selects the strongest set-up channel. When the busy-idle bit signifies the channel is idle, the mobile sends identification and the dialled digits to the control channel of the cell currently serving the mobile subscriber. The mobile unit then waits for a voice channel assignment in that cell and, by supervisiory and signalling tones associated with the assigned channel, provides the necessary answer supervision, disconnect, etc. The set-up channels are used only during the identification, location, and voice channel assignment process. Since this is a big party-line or common channel, occupancy must be limited. Once a two-way voice channel is established between the mobile and the cell site, all supervisory signals occur via in-band (SAT) or out-of-band (ST) tones.

In known cellular systems, during the time that a particular cell has all of the voice channels assigned to previous calls, and thus has voice channel congestion, new requests for mobile service, i.e., voice channel assignment, are denied by that cell. The denial communication sent to the mobile on the control channel in that cell may be absolute or it may optionally include a list of other cells where the mobile may have more success in obtaining a voice channel assignment. This communication is called a "directed retry" in the industry. Fig. 3 is a flow chart of a known directed retry algorithm. The directed retry procedure requires the mobile unit to retune to the control channel of one of the suggested cells and to retransmit all of the specific call detail information. This procedure takes considerable real time (the time has to be added to the other set up times and thus increases the call delay perceived by the human originating the call), represents additional processor load on what may be an already busy system, increases occupancy on the control channels of the current cell as well as of the new cell, and does not ensure success on the new attempt.

During intervals of relatively low traffic volume, such additional burdens, to support directed retry traffic in both mobile originating and mobile terminating call cases on the system, may not substantially degrade the overall number of telephone communications which can be simultaneously handled. However, during intervals of relatively large volumes of telephone traffic, such a burden may limit the amount of telephone communications which can be handled by the system.

In accordance with the principles of the invention, when the system receives a request for service (either a mobile originating call or a call terminating to a mobile) which would normally be denied because of cell voice channel congestion, the system can directly select an idle voice channel in other cells which have coverage areas overlapping the coverage area of the cell or cell sector wherein the subscriber is located. Direct selection is accomplished by the use of a routing table containing alternate routes. The table members of the alternate routes are the available voice channels in the other cells. The communication to the mobile to tune to the selected voice channel in the new cell is sent to the mobile via the control channel of the current cell as would have been the case for the denial or directed retry command. Fig. 4 is a flow chart of an exemplary algorithm which could be used to implement the invention.

The method of the invention is consistent with existing mobile units and the FCC specification (EIA 15–3C), and thus no modification to either is required.

Because of the design of cellular systems as shown in the aforementioned patent applications, the invention is practical to implement. For other system designs where voice channel assignment is performed at each of the several cell sites by their cell site controllers, implementation of the approach of the invention would vary from the implementation for the system of the aforementioned applications, where all of the voice channel assignments for each cell are centralised to the system controller. The benefits derived from the invention, as seen from the subscriber's point of view, would justify the additional cell site controller to cell site controller

communications that could be required for implementation in such other system designs.

From the subscriber's point of view, a voice channel assignment was requested and granted. The subscriber is not informed of, and is indifferent to, the identity of the cell having the assigned voice channel. The call setup time is consistent with the normal case of being served from the same cell. This approach represents the minimum system occupancy as well as the minimum occupancy on the control channels.

The use of routing tables and thus multi-level alternate routing is consistent with selecting idle voice channels from a free list rather than following a fixed search pattern scheme.

The use of alternate routing to an idle voice channel in another cell can be used in those call cases where the RF coverage of the mobile from the new cell can be inferred from the cell overlap topology. This may be the case with overlayed cells, as seen in City A of Fig. 2, as well as cells with different power levels, cell site boundaries, etc.

The alternate routing scheme should be considered as a one-way selection, or overflow, from cell A to cell B but not from cell B to cell A. Bidirectional relations are thus not required but where they do exist they may be covered by an entry of an alternate route to cell A in the routing table for cell B. Fig. 5 is a diagram of the coverage areas of three cells. Hence, in Fig. 5, cell 1 may alternate route to cell 2, but must use directed retry to cell 3. Also, cell 2 must use directed retry to both cell 1 and cell 3. As a further example, Fig. 6 is a diagram of the coverage areas of three cells, including sectored cell 1. Hence, in Fig. 6, cell 1, sector 1 may alternate route to cell 2, but must be directed retry to cell 3. Also, cell 2 must use directed retry to both cell 1 and cell 3. Additionally, cell 1, sector 2 may alternate route to cell 3, but must use directed retry to cell 2.

Directed entry remains a viable solution for those call cases where cell conditions do not allow for the alternate route or when the alternate route also has congestion.

CLAIMS

1. A method for routing cellular mobile radio telephone calls, comprising monitoring cell call activity for assignment of an idle voice channel to a mobile subscriber, and directing the mobile subscriber to an idle voice channel in another cell in response to detection of cell call congestion.

2. A method for routing cellular mobile radio telephone calls substantially as described with reference to Figs. 4, 5 and 6 of the accompanying drawings.

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